FAIRBANKS MORSE ENGINE

RTG20 TURBINE SYSTEMS

Landfill Methane Outreach Program

7th Annual Conference and Project Expo

January 6-7, 2004

LANDFILL METHANE OUTREACH PROGRAM

FAIRBANKS MORSE ENGINE

- Located in Beloit, Wisconsin U.S.A.
- Established engine manufacturer since 1893.
- Manufacturing facilities renovated in 2002.
- Largest reciprocating engine manufactured in U.S.
- Approximately 600,000 ft.^{2} under roof.
- Operating division of EnPro Industries, Inc.
  - NYSE: NPO
  - $850 million in revenue

FAIRBANKS MORSE ENGINE

PRIMARY MARKETS

POWER GENERATION AND CHP

NAVY MARINE PROPULSION AND ELECTRIC POWER GENERATION

FAIRBANKS MORSE RTG20
RADIAL TURBINE POWER SYSTEMS

- Low operating cost - Up to 80% thermal efficiency with cogeneration
- All Radial Design - ISO 1.75 MWe
- Can operate on both natural gas and diesel fuel with low exhaust emissions (NOx and CO)
- NOx < 6 ppm on natural gas
- NOx < 20 ppm on diesel fuel
- Inherent turbine availability > 98%
- Low installed cost due to package design

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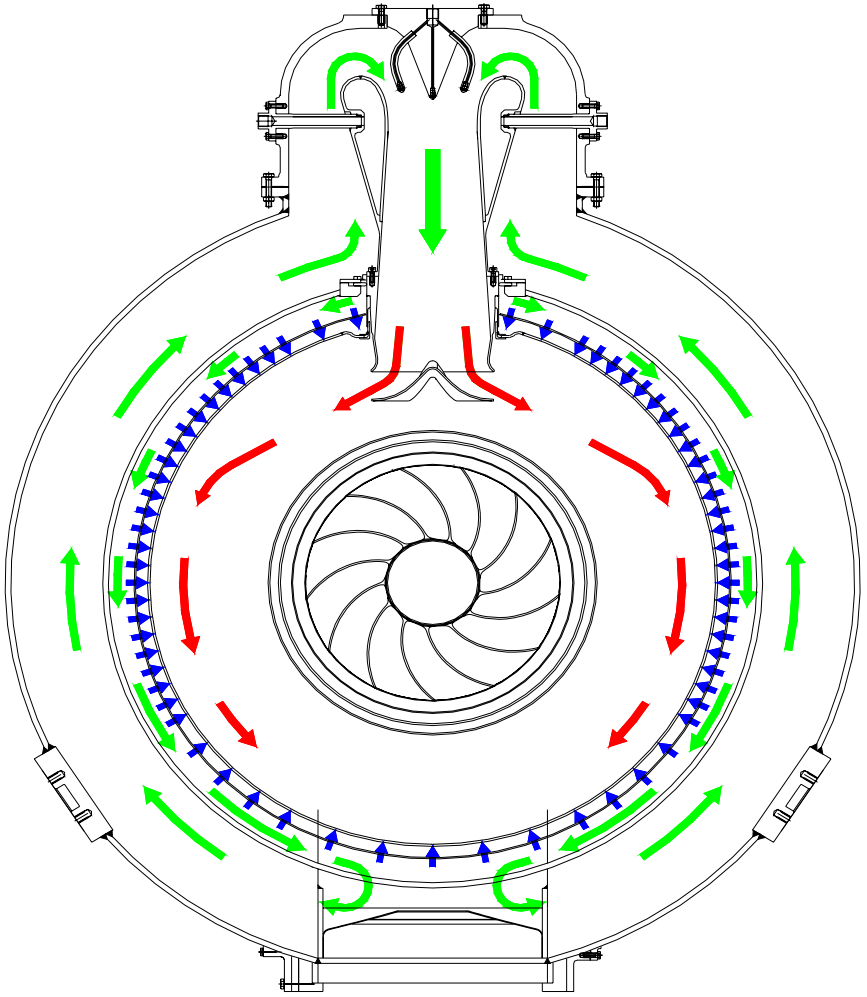
RTG20 DESIGN FEATURES

PATENTED COMBUSTOR:

- COFAR™(Controlled Fuel Air Ratio) system
- Single stage annular configuration.
- Single venturi pre-mixer with dual exit nozzle
- Air modulating valve for controlled F/A ratio over entire operating range
- Convection cooling for low pattern factor, low CO emissions and long life
- Dual fuel capability
- Dry low emissions available on both gaseous and liquid fuel



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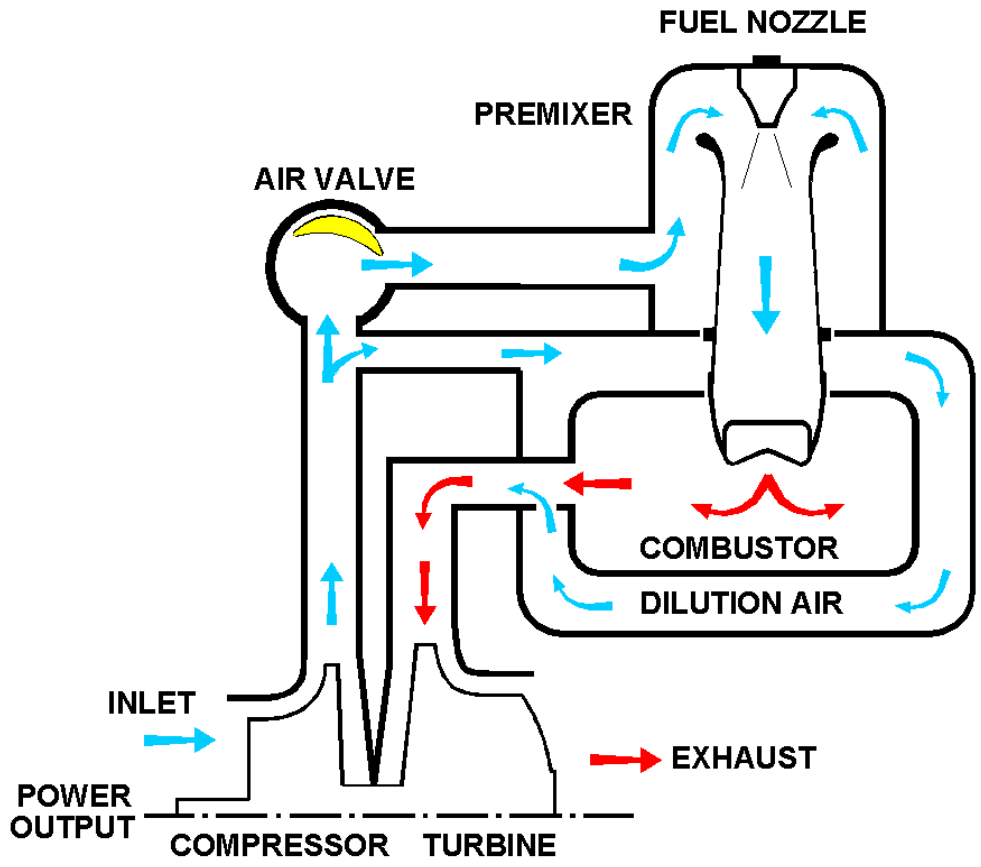
COFAR™ COMBUSTION PRINCIPLE



- The COFAR combustion system is designed for efficiency and low NOx and CO emissions across the entire operating range, without complex catalytic combustion or exhaust after-treatment.
- With varying load (and fuel flow), the air valve admits the precise amount of combustion air to provide a lean mixture, resulting in low flame temperature and low emissions at all load levels. When the air valve closes, more dilution air enters upstream of the turbine. **No air is lost from the cycle**.

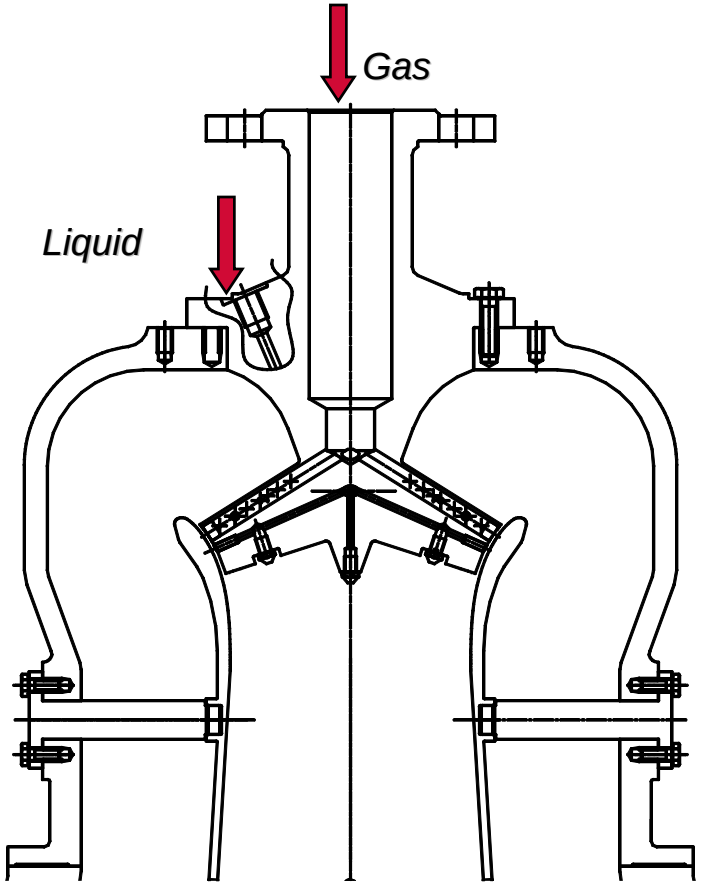
RTG20 DESIGN FEATURES

DUAL FUEL NOZZLE:

- **Fuel preparation is essential for low emissions**

Main Design Features:

- Single fuel injector
- Single stage injection - simplified fuel system
- 4 Winglets
- 5 high pressure liquid fuel atomizers (100 bar)
- SMD = 10 microns for DF-2
- 56 gas holes injecting perpendicular to air flow
- Design optimised for atomisation (liquid) and fuel placement (gas and liquid)



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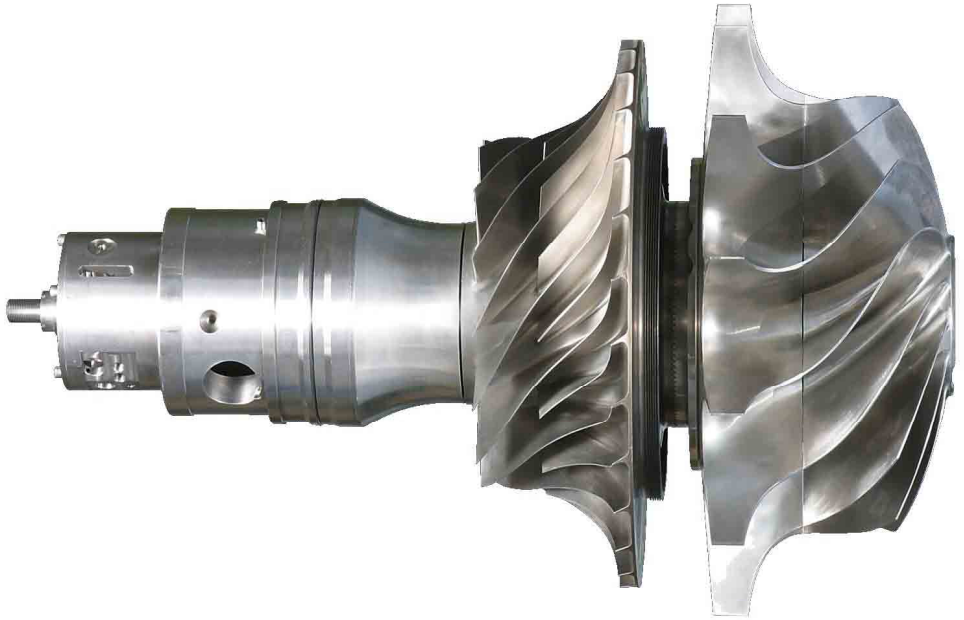
RTG20 DESIGN FEATURES

ROTOR CARTRIDGE:

- All radial overhung rotor configuration
- Both bearings in cold section
- Sub-critical rotor dynamics
- Hybrid bearing system selected for low frictional loss, good damping and long life
- Pre-balanced cartridge offers good balance integrity and ease of assembly / service



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RTG20 Package Design

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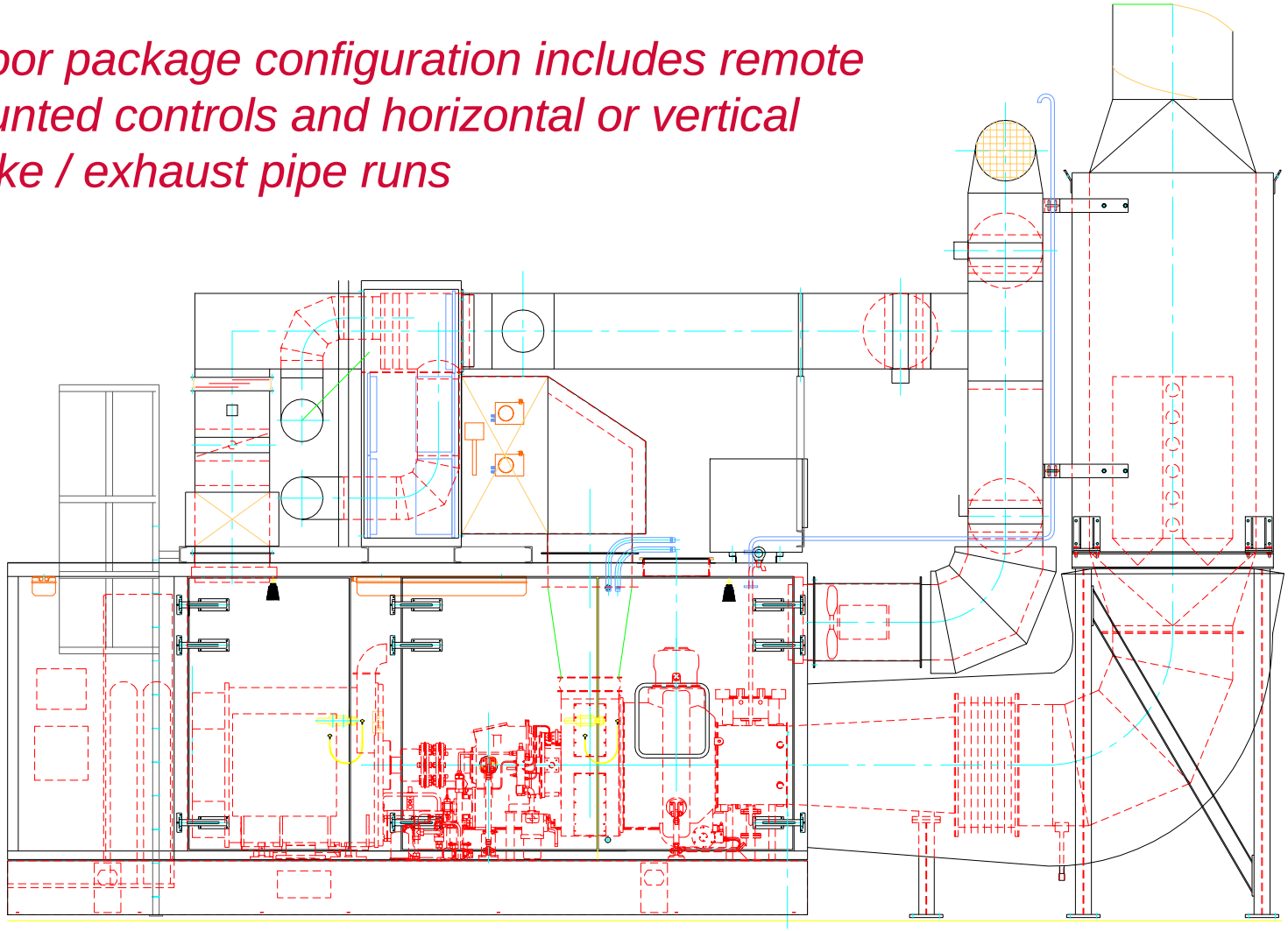
TYPICAL RTG20 OUTDOOR PACKAGE

Indoor package configuration includes remote mounted controls and horizontal or vertical intake / exhaust pipe runs



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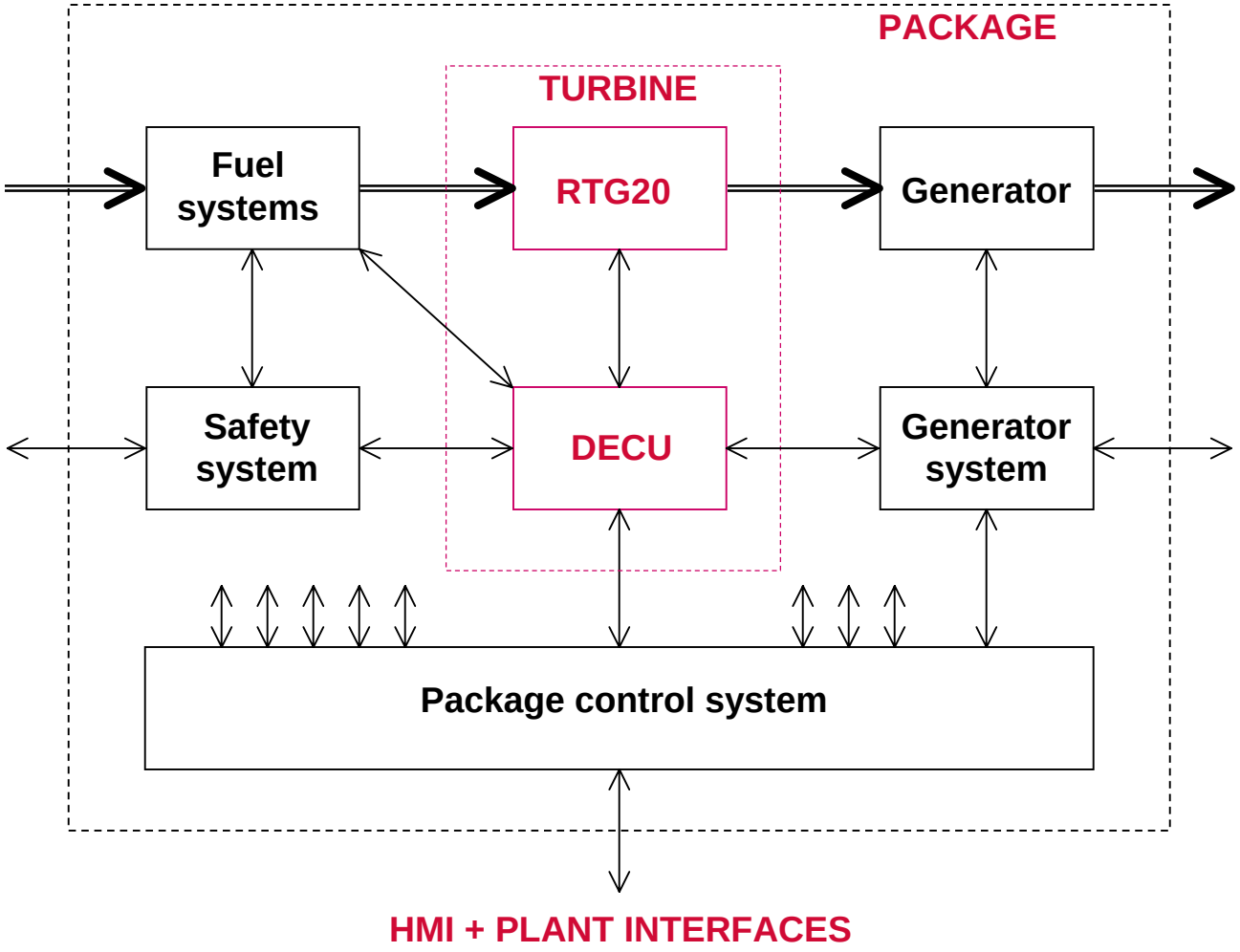
CONTROLS OVERVIEW



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MARKETS / APPLICATIONS

- **Distributed Electric Power Generation**
  - Stand-by applications (quick-start) with emissions considerations or space / weight restrictions
  - Peak shaving applications - industrial and institutional with focus on high heat loads
  - Continuous duty (island and grid parallel) - process industries and institutional (high heat loads).
- **Fuel Switching and Opportunity Fuels**
  - Gas driven industrial applications
  - Landfill gas, bio-gas, and stranded gases
- **Remote Site Power Generation**
- **Offshore Gas Production Platforms**
- **KG2 “Drop-in” Replacement (Predecessor Turbine)**

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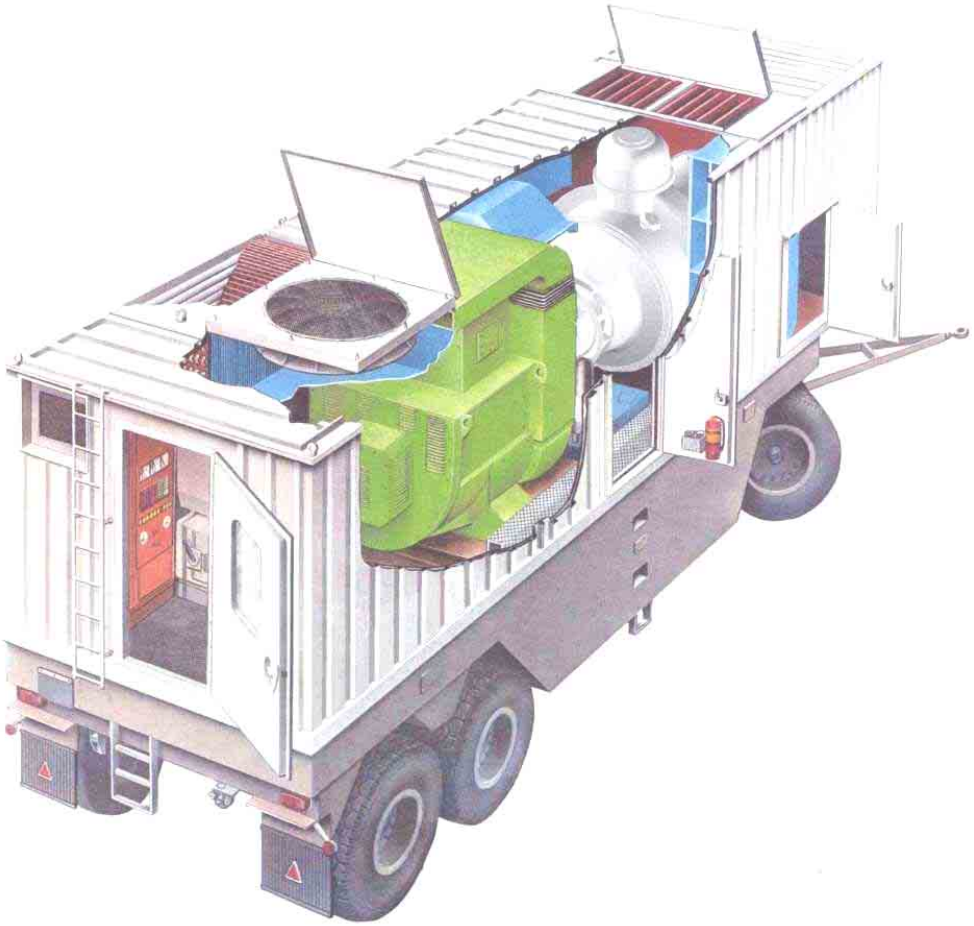
MARKETS / APPLICATIONS

MOBILE STAND-BY APPLICA

- Emergency stand-by
- Utility grid-support
- 30-second start-up an advantage over axial turbines
- Low emissions on diesel fuel (<20 ppm) - an advantage over reciprocating engines



Conceptual design of an RTG20 turbine-powered mobile generator set - 1.7 MW

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TECHNOLOGY BENEFITS
LANDFILL GAS APPLICATIONS

- Lower supply pressure requirements than axial turbine technologies - 150 psig for natural gas
- Lowest NOx emissions in the 1,500 - 2,000 kWe range - 6 ppm for natural gas without after-treatment or catalytic combustion
- Robust rotor and combustor design resists corrosion and damage due to fuel quality
- **AVAILABILITY, RELIABILITY AND DURABILITY**

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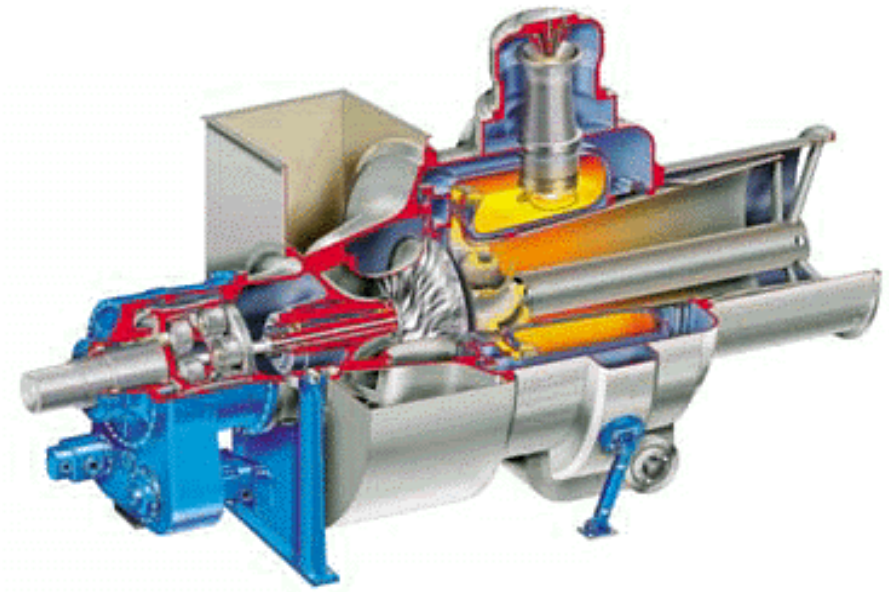
TECHNOLOGY BENEFITS
LANDFILL GAS APPLICATIONS

- Moderate firing temperatures reduce formation of siloxanes
- Conservative turbine temperatures due to tangential tip velocity
- No cooling apertures in hot sections where burned fuel is present
- Reduction in power output (due to BTU content of fuel) can be minimized with slightly higher gas pressures



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TECHNOLOGY BENEFITS
LANDFILL GAS APPLICATIONS

- Pre-engineered package design with enclosure minimizes installation time and expense - small footprint
- Modular package can suit a variety of landfill project sizes
- Overall efficiency improvement available with heat recovery ~ 12,000 lb/hr of 125 psig steam production capability
- Capability to utilize #2 diesel fuel as a supplement to landfill gas if required

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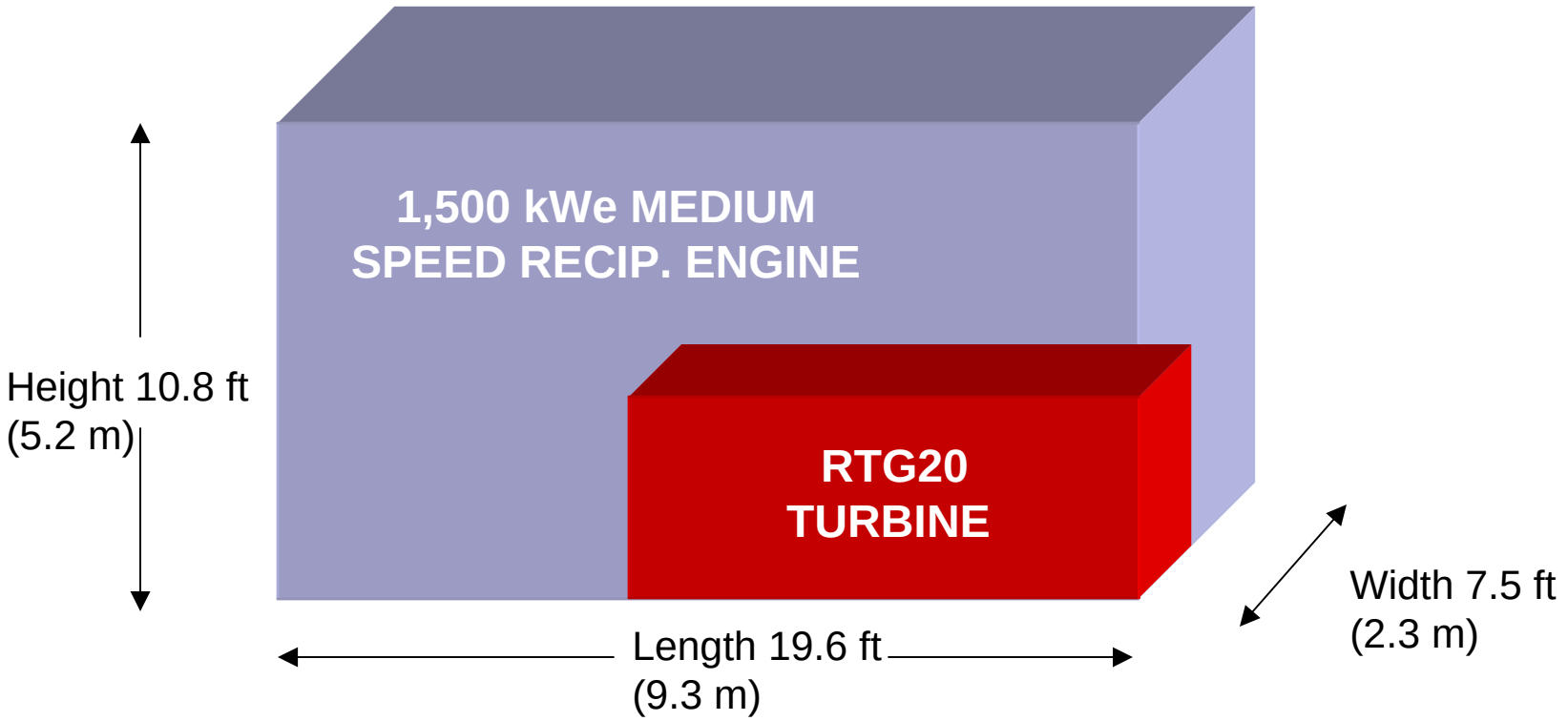
INSTALLATION COMPARISON
RTG20 TURBINE VS. RECIPROCATING ENGINE

TO SCALE



75% FOOTPRINT ADVANTAGE

89% VOLUME ADVANTAGE

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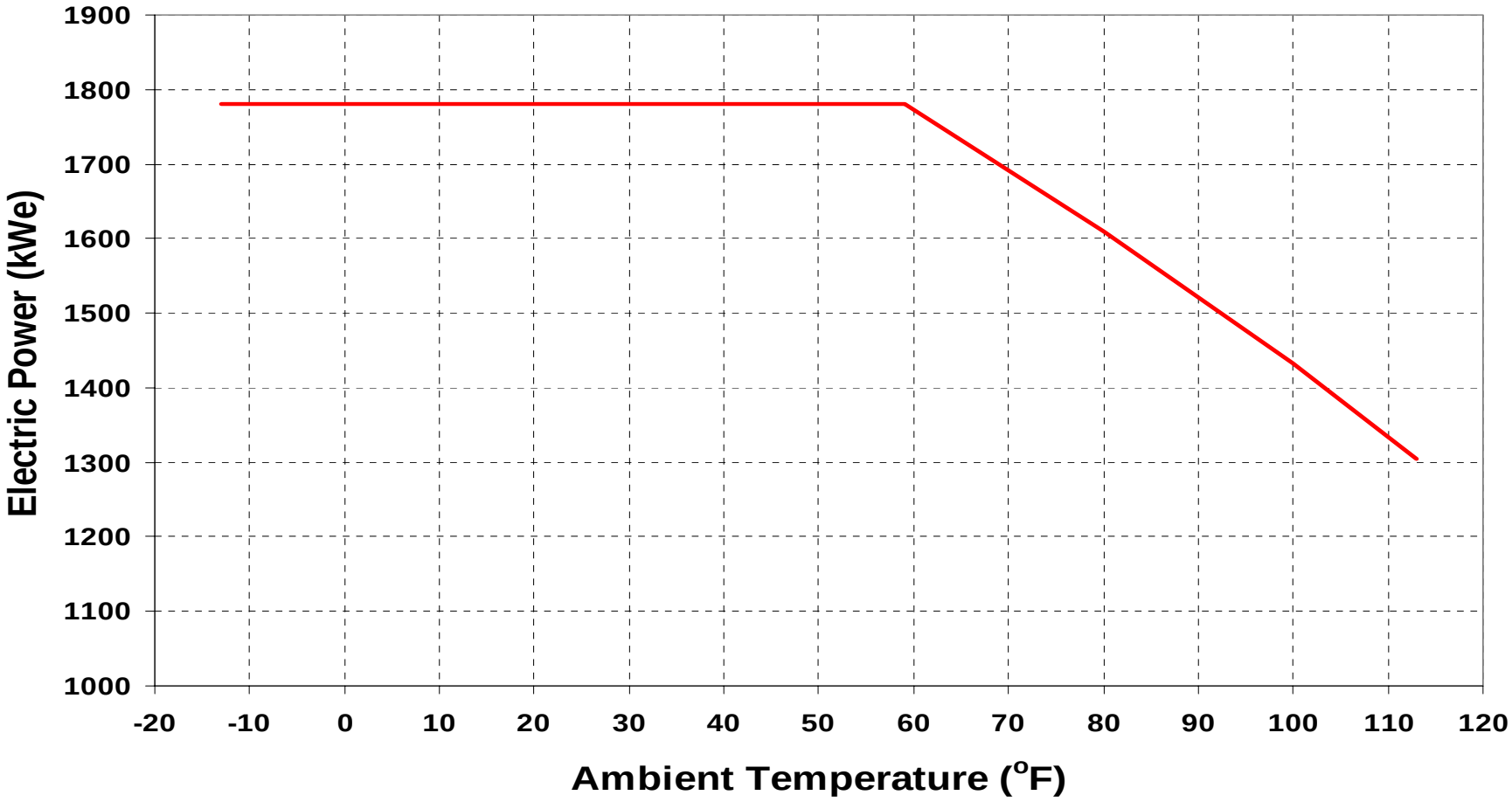
ELECTRICAL OUTPUT VS. AMBIENT

ISO CONTINUOUS RATING - NATURAL GAS



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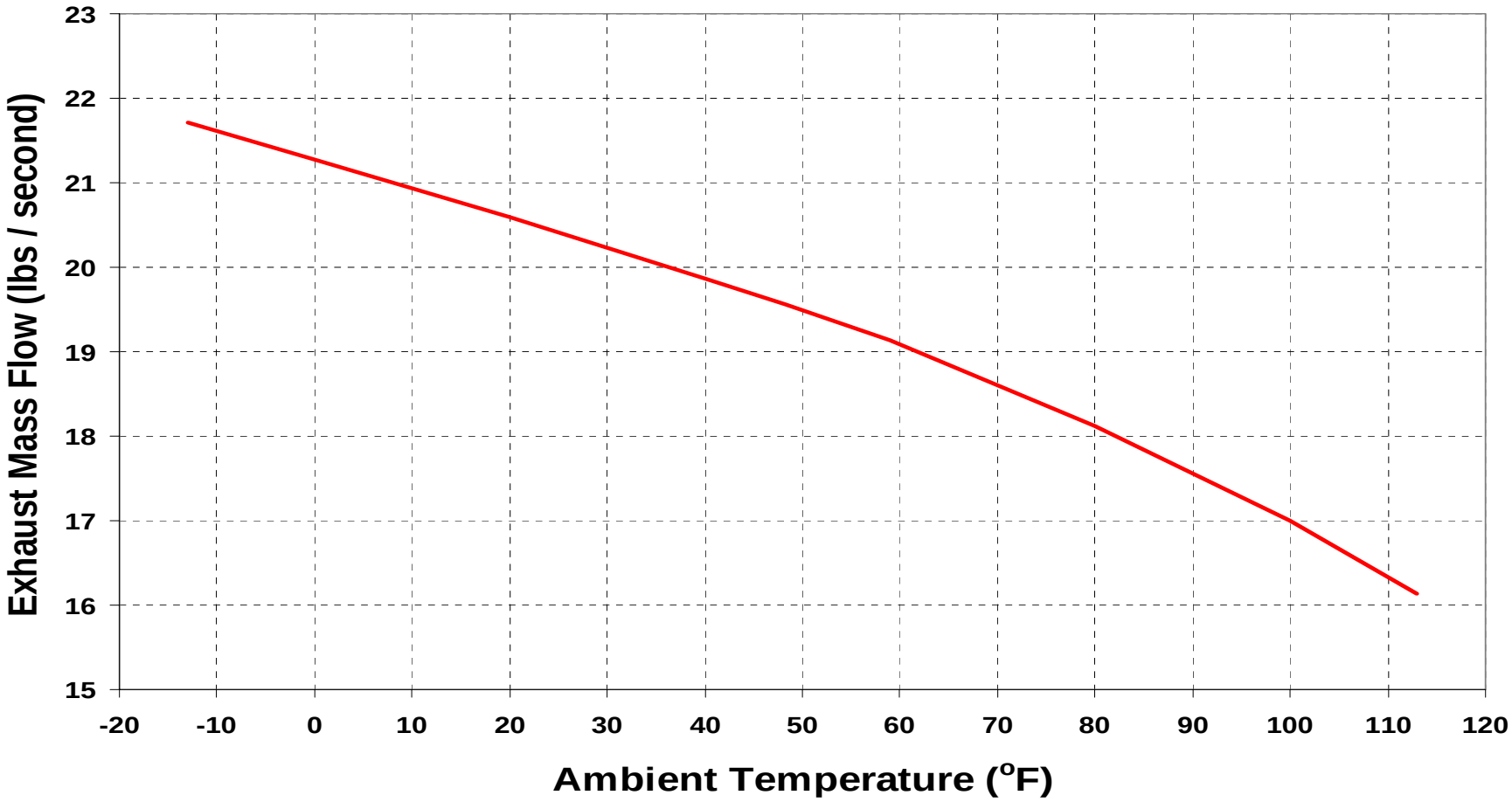
EXHAUST MASS FLOW VS. AMBIENT

ISO CONTINUOUS RATING - NATURAL GAS



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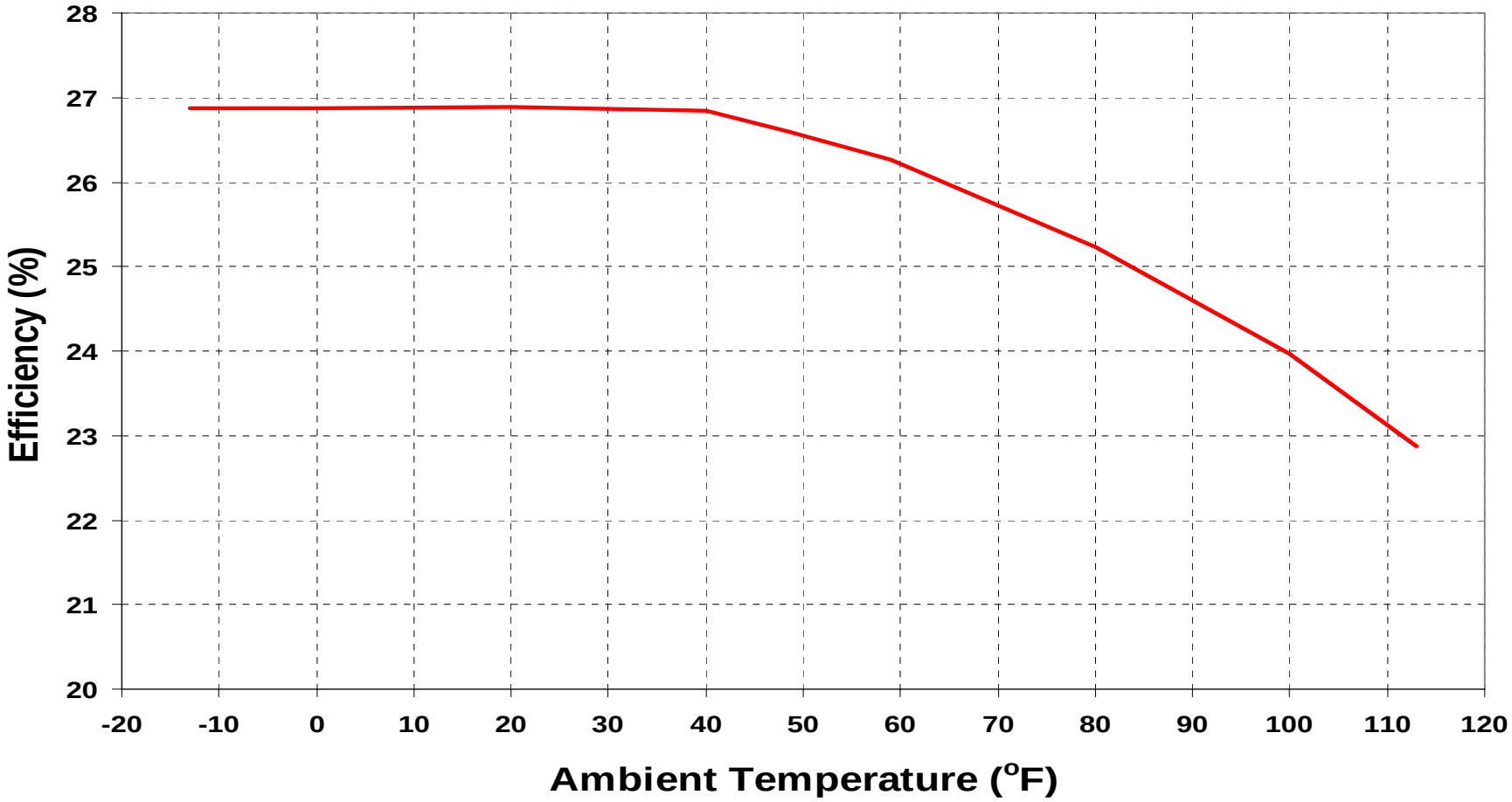
EFFICIENCY VS. AMBIENT

ISO CONTINUOUS RATING - NATURAL GAS



AFTERMARKET SUPPORT

- **Spare Parts**
  - Standardized engine / package designs
  - 24/7 Availability
  - Core-engine exchange capability designed into the package
- **Service Support**
  - Turbine service technicians available 24/7
  - Traditional “portal-to-portal” service
  - Long-Term Service Agreements
  - “Guaranteed Power”
  - Continuous Remote Monitoring - *Connected Energy*

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www.fairbanksmorse.com